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Streamlined Reliability Centered Maintenance (RCM)

Tutorial and Application (RCM.ppt / R6.exe)

by
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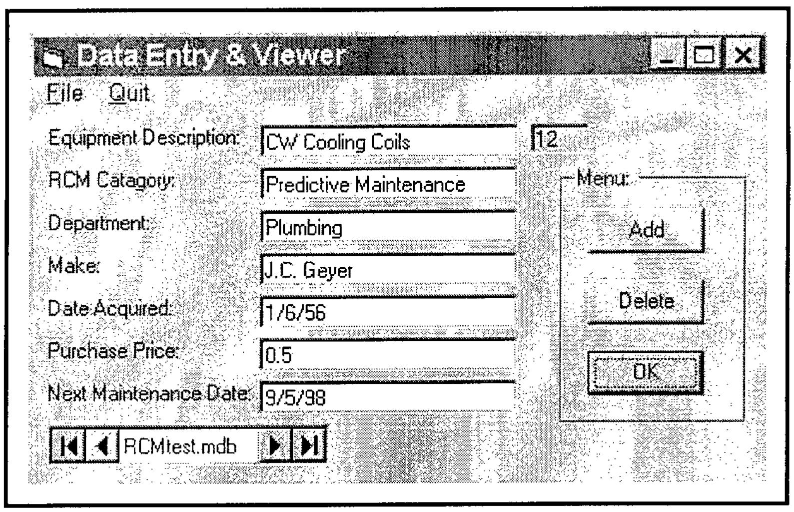

This report provides an outline of a tutorial and application designed to educate facility managers about efficient building maintenance using Reliability Centered Maintenance (RCM). The tutorial evaluates the advantages and disadvatages of four maintenance methods to help maintenance managers evaluate their current equipment maintenance methods. The cost benefits of implementing a different type of RCM based on the cost of maintenance could be significant. RCM can prevent "over maintaining" by saving mechanical labor time as well as maintenance dollars.

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This report provides an outline of a tutorial and application designed to educate facility managers about efficient building maintenance using Reliability Centered Maintenance (RCM). The tutorial evaluates the advantages and disadvatages of four maintenance methods to help maintenance managers evaluate their current equipment maintenance methods. The cost benefits of implementing a different type of RCM based on the cost of maintenance could be significant. RCM can prevent "over maintaining" by saving mechanical labor time as well as maintenance dollars.

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Foreword

This study was conducted for Madigan Army Medical Center under Project 4A162720D048, "Industrial Operations Pollution Control Technology," Work Unit U58, "Enhanced O&M of Pollution Control Equipment." The technical monitor was Michael Carico, MAMC-FMD.

The work was performed by the Environmental Processes Branch (CN-E), of the Installations Division (CN), U.S. Army Construction Engineering Research Laboratory (CERL). The CERL principal investigator was Jearldine I. Northrup. Mark W. Slaughter is Chief, CECER-CN-E and Dr. John T. Bandy is Chief, CECER-CN. The CERL technical editor was William J. Wolfe, Information Technology Laboratory.

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1 Introduction

Background

Reliability Centered Maintenance (RCM) was a maintenance concept developed in the airline industry during the late 1960s. Keeping a fleet of aircraft in service is a maintenance-intensive effort. Performing preventive maintenance (PM) on the fleets took many resources. Airline companies wanted to see if they could maintain their fleets at the same level of quality at a lower cost. A strong correlation between age and failure rate did not exist. This indicated that time-based PM was inefficient for the majority of equipment.

A new RCM program incurs an initial investment to obtain technological tools, training, and equipment condition baselines. This initial increase in maintenance costs due to RCM is short-lived. The cost of reactive maintenance decreases because failures are prevented and condition monitoring (CM) replaces preventive maintenance tasks. This results in a reduction in both reactive maintenance and total maintenance costs. Energy savings may also be expected from the use of CM that is part of any RCM program. A further cost savings from adopting RCM is that the program obtains the maximum use from equipment. RCM allows maintenance managers to replace equipment based, not on calendar, but on actual equipment condition. This condition approach to maintenance extends the lives of both the facility and its equipment. Even though maintenance only accounts for a relatively small portion of the overall life cycle costs of a facility, a balanced RCM program can achieve savings of 30 to 50 percent in a facility's annual maintenance budget.

In addition to PM, RCM recognizes other maintenance strategies including run-to-failure, predictive maintenance, and proactive maintenance. Each maintenance strategy suits a different equipment type. This project was undertaken to provide Army installations the capability to select the appropriate maintenance strategy from RCM in specific situations to maintain its equipment and optimize production and services.

Objectives

The objectives of this study were to:

1. Examine the principles of RCM as a means of optimizing maintenance activities and minimizing degraded performance or failure.
2. Prepare a "primer" to teach novices and to give experienced facilities maintenance staff members a "refresher course" in the principles of RCM.
3. Create a tutorial application that could help evaluate whether the maintenance being performed on a piece of equipment was correct.

Approach

Each of the various maintenance strategies included in RCM is individually suited for specific pieces of equipment. The different maintenance strategies were approached and their advantages and disadvantages documented. An RCM logic tree was constructed to help a maintenance manager to select the appropriate maintenance strategy for a particular piece of equipment.

Mode of Technology Transfer

The RCM Tutorial and Application will be available on the CERL web page:

http://www.cecer.army.mil/

2 Categories of Reliability Centered Maintenance (RCM)

RCM recognizes the value of your personnel and takes advantage of their extensive experience running the facility/equipment.

- *Run to Failure (RTF)* works on the assumption that it is most cost effective to let equipment run unattended until it fails. This type of maintenance is used on the lowest priority equipment.
- *Preventive Maintenance (PM)* comprises maintenance tasks on a piece of equipment at regular intervals whether the equipment needs it or not.
- *Predictive Maintenance (PDM)* is maintenance based on real-time data collected on a piece of equipment. The data show the "health" of the equipment.
- *Proactive Maintenance (PAM)* determines the root causes of failure and implements "fixes" (e.g., redesign the equipment so that it does not break down as frequently).

Run-to-Failure

Run to Failure follows the old adage "if it ain't broke, don't fix it." Up to the time of machinery failure, this method requires the least support from the maintenance crew. The equipment is run with very little or no surveillance or monitoring. When it fails catastrophically or can no longer perform its function, it must simply be replaced. In spite of the high product loss, capital equipment loss, total manpower expenditure, and accident rate, RTF is still the predominant method of plant operation in the United States. Such philosophy is especially dangerous when the equipment is nonstandard and has a long lead-time for replacement.

Preventive Maintenance (PM)

When well implemented, PM may produce savings in excess of 25 percent. Beyond the savings potential, the benefit quickly approaches a point of

diminishing return. PM involves the periodic checking of the performance or condition of a piece of equipment to determine if its operating conditions and resulting degradation rate are within expected limits. If the findings indicate that the degradation rate is more rapid than anticipated, the problem must be found and corrected before equipment failure occurs. Mean-Time-Between-Failure (MTBF) is a parameter often used to set PM schedules, but it must be an average failure rate over time. The PM method is very labor-intensive and often involves unneeded maintenance. Even though PM is an improvement over RTF, abrupt failures that cause unscheduled downtime still occur.

Predictive Maintenance (PDM)

PDM has shown additional savings over preventive maintenance. The use of "real time," or portable instruments that monitor vibration, thermography, and ferrography, has been useful in recognizing signs leading up to machine failure. Other tools used in predictive testing and inspection are trend analysis, pattern recognition, data comparison, tests against limits and ranges, correlation of multiple technologies, and statistical process analysis. PDM is aimed at detecting the degradation mechanisms themselves and eliminating or controlling them before any significant physical deterioration of the equipment occurs. The main benefit of PDM is the earlier warning (from a few hours to a few days) that reduces the number of breakdown failures. PDM is usually implemented concurrently with preventive maintenance. It targets both the warning signs of impending failure (such as overheating bearings) and the recognition of small failures that begin the chain reaction that leads to catastrophic failures. For example, when an automobile's serpentine fan belt breaks, the failure is not isolated to the single component (the belt). The failure can damage several other components before the belt falls off.

Proactive Maintenance (PAM)

In some cultures, equipment was built to last for 100 years when used for a specific job. Today, all equipment must compete with open market where many manufacturers are designing for failure at a given life time, usually much shorter than 100 years. The owner of a piece of equipment must now try to determine what the manufacturers had in mind when the equipment was designed to properly anticipate failure or replacement needs. This is no easy task. No engineer knows all there is to know about materials that will impact the life of the equipment.

The PAM approach replaces the maintenance philosophy of "failure reactive" with "failure proactive" by avoiding the underlying conditions that lead to machine faults and degradation. PAM is presented as an important means to cure failure root causes and extend machine life. Unlike predictive/preventive maintenance, proactive maintenance looks at failure root causes, not just symptoms. Its main premise is to extend the life of mechanical machinery as opposed to: (1) making repairs when often nothing is broken, (2) accommodating failure as routine and normal, or (3) pre-empting crisis failure maintenance. Ideally, in the future, machinery should include contaminant and/or performance sensors for real-time proactive maintenance and condition control.

Expert system software combined with strategically located sensors and transducers (e.g., pressure, temperature, vibration, viscosity, wear debris, and moisture) will provide comprehensive machine health monitoring for the most sophisticated future machine applications. In this report, the concept of PAM would result in equipment redesign (which is the purview of the equipment builder) or provisions for redundant equipment — to ensure longer life before the equipment is purchased. Redundancy can effectively cost two or three times the cost of the critical machine, but it can reduce the loss of service to near zero.

3 Reliability Centered Maintenance (RCM) Program

Overview of Tutorial

The RCM tutorial, prepared using Microsoft PowerPoint® 97 software, was designed to educate facility managers in economic efficiency when maintaining building equipment. Calendar-based preventive maintenance is not optimal for all types of equipment. Determining the type of RCM a piece of equipment falls under will prevent over maintaining the piece of equipment.

The tutorial defines RCM in four categories:

1. Run to Failure (RTF) assumes that it is most efficient and economical to replace the equipment only upon failure.

2. Preventive Maintenance (PM) executes a list of maintenance tasks against a piece of equipment on regular intervals.

3. Predictive Maintenance (PDM) requires the collection of sample data to determine the "health" of a piece of equipment.

4. Proactive Maintenance (PAM) looks for the root causes of repeated failures based on the feedback from the user to the equipment manufacturer, rather than just treating the symptoms.

A comparative chart outlines the advantages and disadvantages of each type of maintenance (Figure 1).

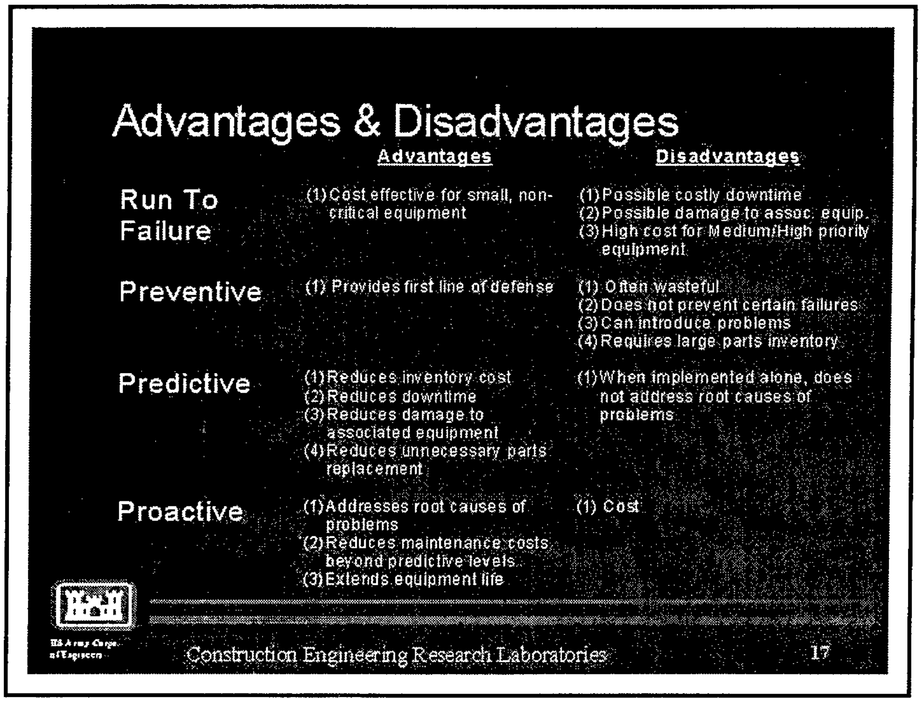

Figure 1. Advantages and disadvantages of each type of maintenance.

Proactive Maintenance (PAM) that looks at root failure of equipment is the optimal solution because cost is the only disadvantage. However, nothing is perfect. Buildings always go through a "building shakedown." Setting up an RCM program will help get facility managers pointed towards proactive maintenance.

The RCM logic tree is illustrated so that a facility manager can briefly think about what type of maintenance should be used for a piece of equipment (Figure 2). General and more specific questions (Figure A2) are then asked about each type of maintenance to get an idea of what kinds of costs will be associated with each type of RCM.

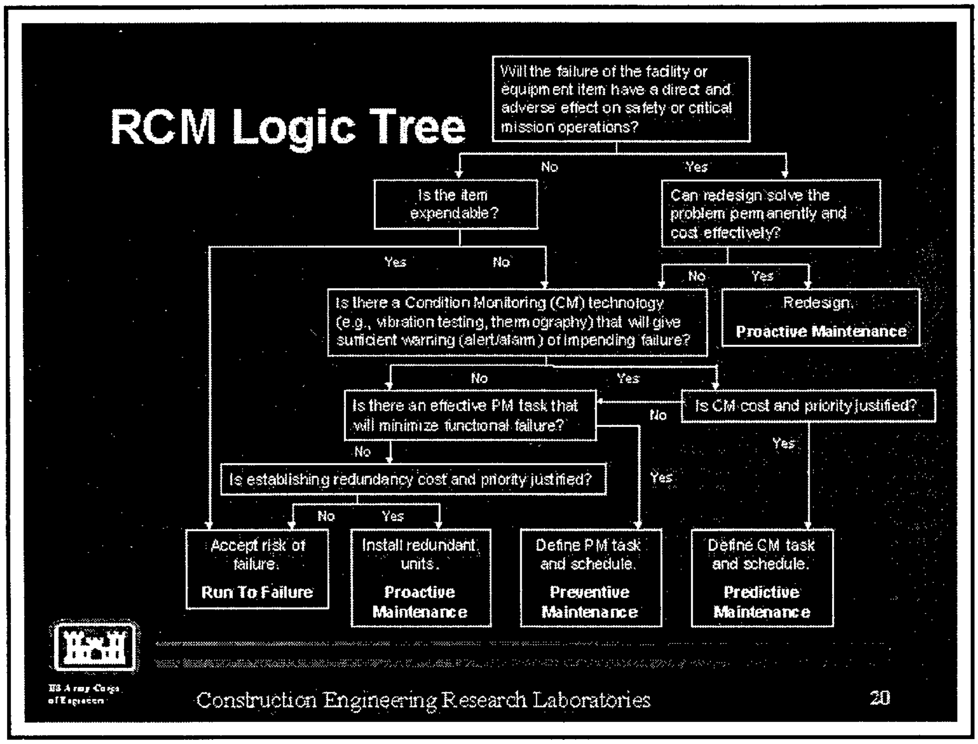

Figure 2. RCM logic tree (source: *NASA Facilities RCM Guide*, pp 2-3).

Predictive Maintenance (PDM) is commonly used but has many questions associated with it. What kind of data should be collected? How are the data collected and how frequently? What kind of hardware do I need? The data are gathered just to gain a quick indication of the "health" of a piece of facility equipment. Examples of predictive maintenance technologies follow. For example, lasers provide a quicker and more accurate means of shaft alignment and balancing than dial gauges (Figure 3). Note that the RCM logic tree (Figure 2) does not cover the fact that some PM is required in conjunction with some PDM strategies. For example, in performing maintenance on chillers, both PM and PDM strategies are performed.

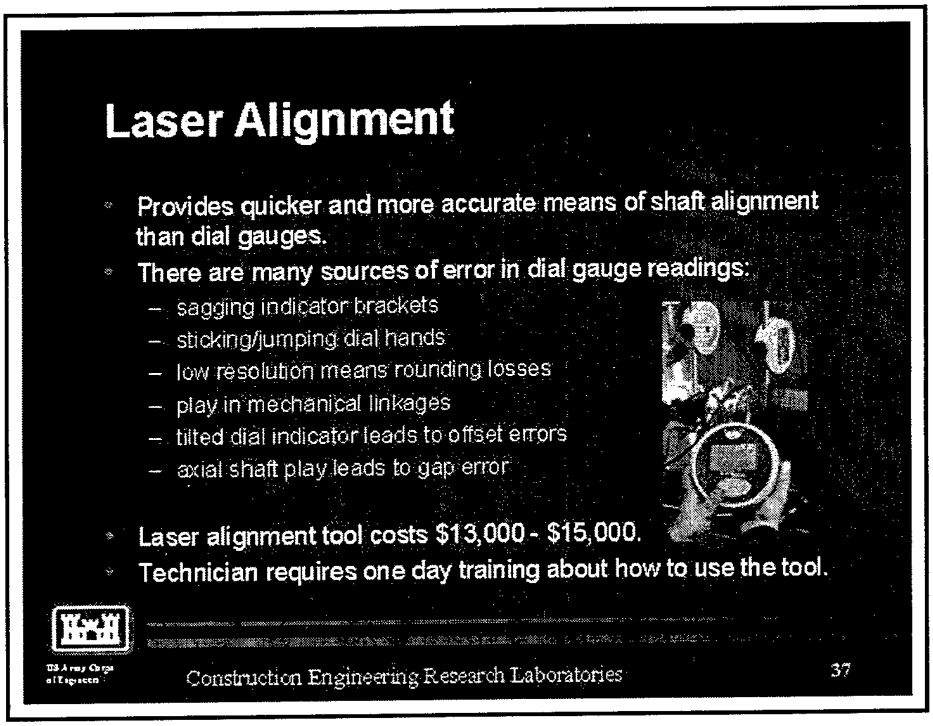

Figure 3. Laser alignment.

An RCM exercise (Figure 4) finishes the tutorial. A button on the last slide will launch the RCM Application that is explained in the following section of this report.

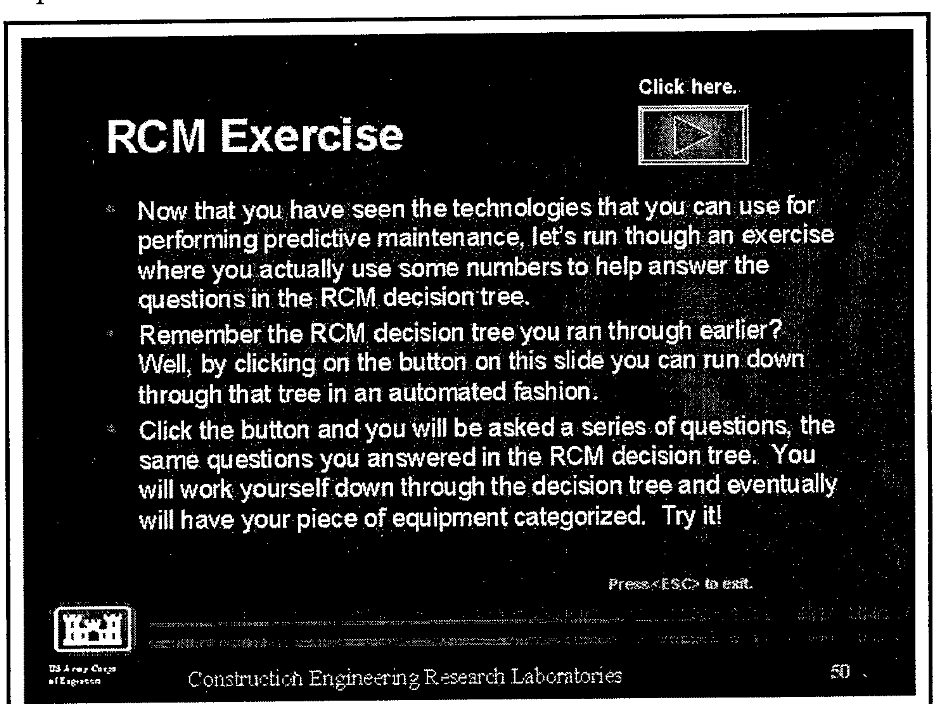

Figure 4. Launch RCM application from RCM exercise.

Overview of Application

The RCM Application can be launched from Microsoft PowerPoint® 97 or used as a standalone application. Message boxes (Figure 5) will guide the user throughout determining the type of RCM most appropriate for a piece of equipment. A reset button allows the user to go through the exercise many times without restarting the program. Pull down menus (Figure 6) offer accessibility to the cost calculators and data entry into the Microsoft Access® database.

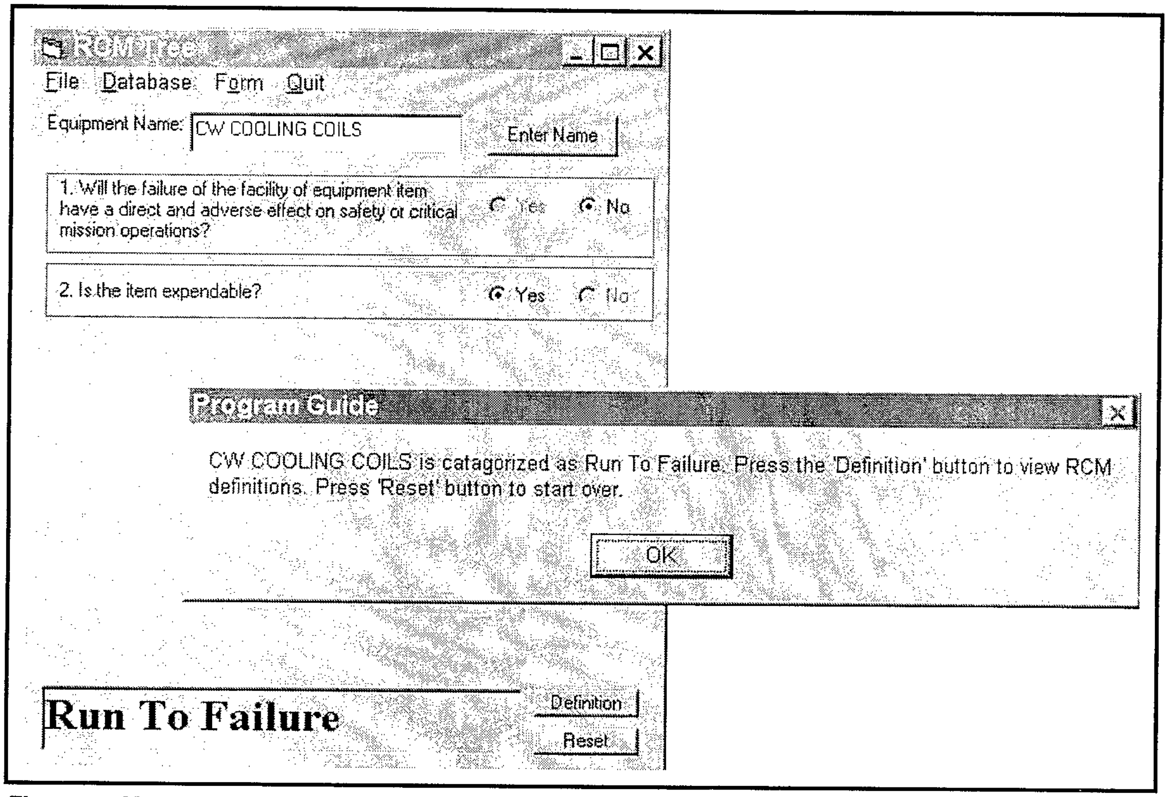

Figure 5. Message boxes guide the user through the program.

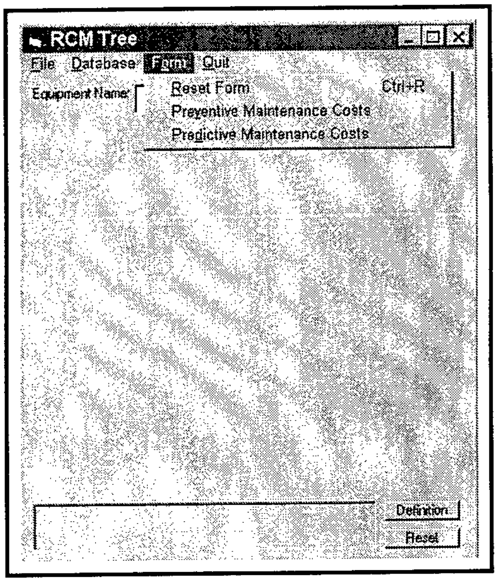

Figure 6. Pull down menus.

The RCM Application takes the user through the decision tree (Figure A3), adapted from the one seen earlier (Figure 3), and explains the definitions (Figure A4) of each type of RCM in a summary format. Cost calculators are available for Preventive Maintenance (Figure A5) and Predictive Maintenance (Figure A6) cost estimations. Data can then be entered into a database – accessible with Microsoft Access® – through the data entry form (Figure 7).

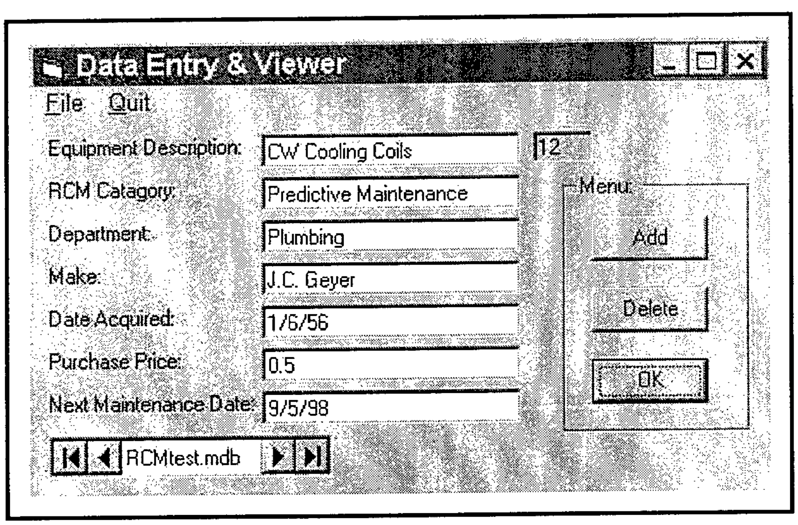

Figure 7. Data entry form.

References

Davis Instruments
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Fax: (800) 433-9971 or (410) 358-0252
www: http://www.industry.net/Davis.Instruments
Reference: Catalog, Volume 62

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Fax: (914) 347-2181
www: http://www.epdtech.com
Reference: Instruments For Industry, Volume 6

Land Infrared
Division of Land Industries International Inc.
2525 Pearl Buck Road
Bristol, PA 19007
Tel: (215) 781-0700
Fax: (215) 781-0723
Reference: Brochures
Cyclops Compac 3 – Portable Infrared Thermometers
Cyclops T1 35 – Thermal Imaging System
Thermovision 210 – Infrared Thermal Viewer
R S Means, 1998

Appendix A: Referenced Screen Shots

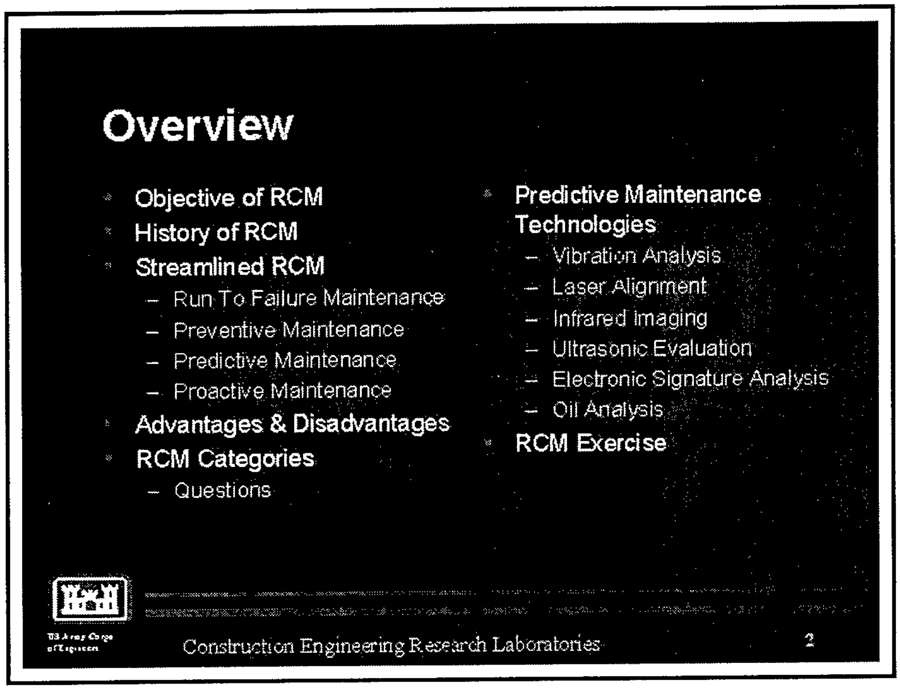

Figure A1. Overview of tutorial.

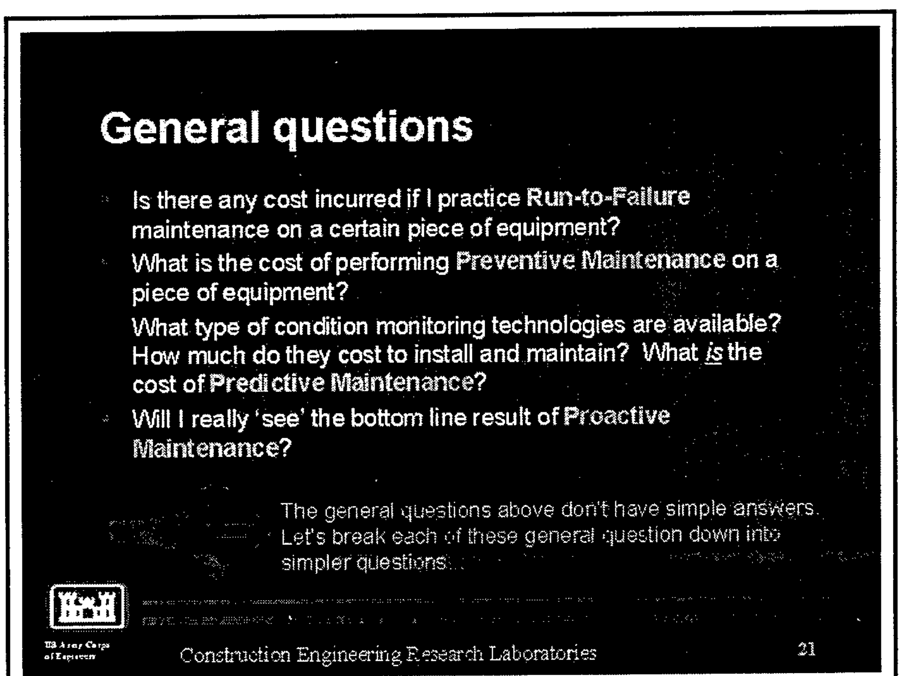

Figure A2. General questions for each type of RCM.

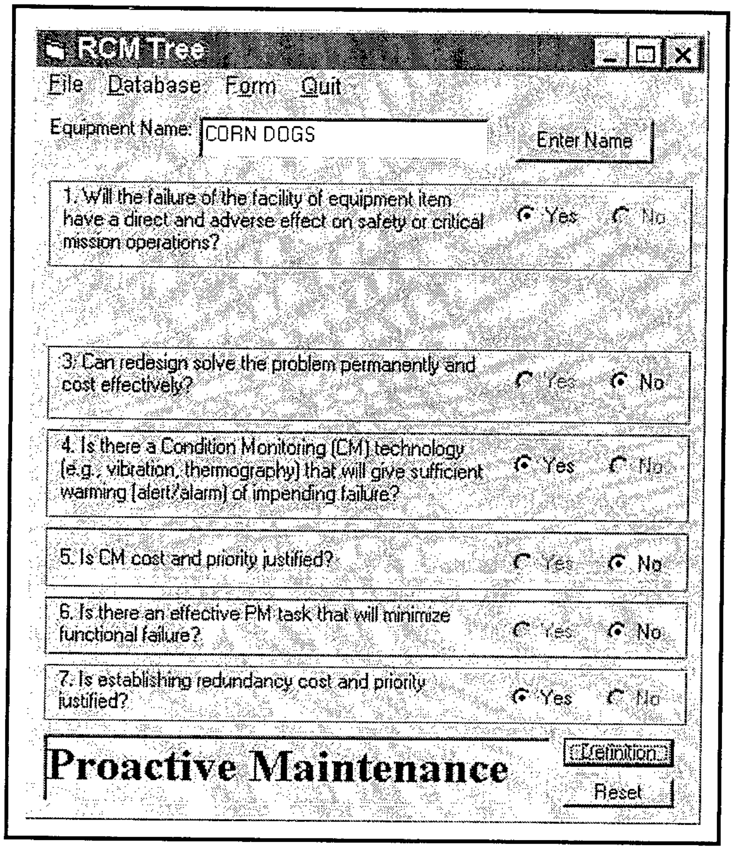

Figure A3. RCM tree.

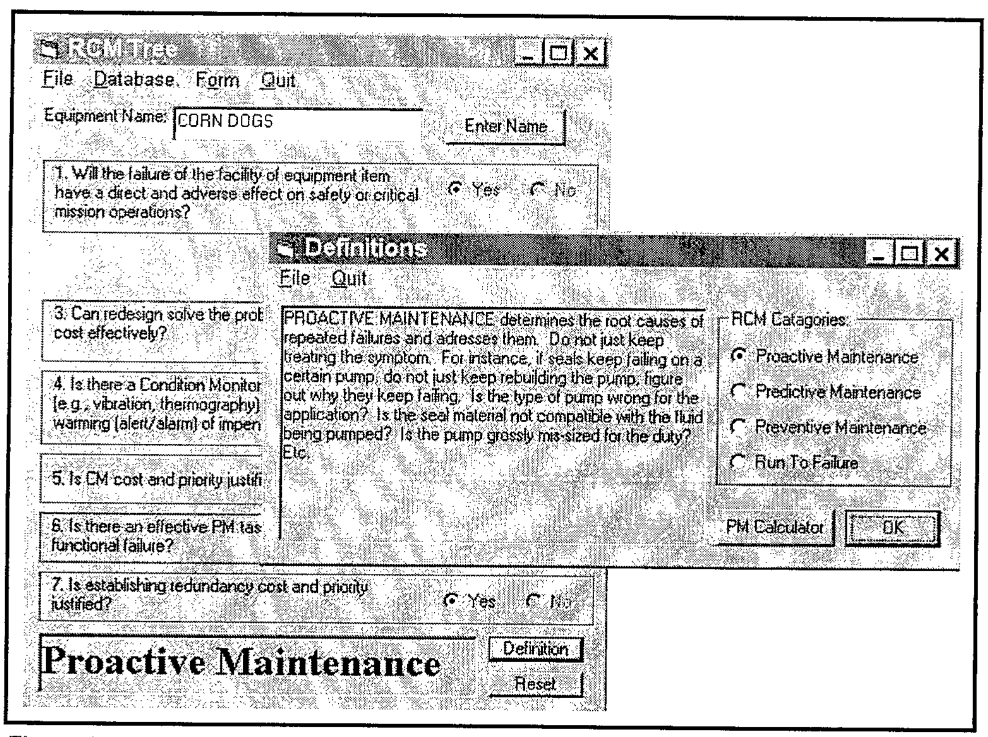

Figure A4. RCM categories definition box.

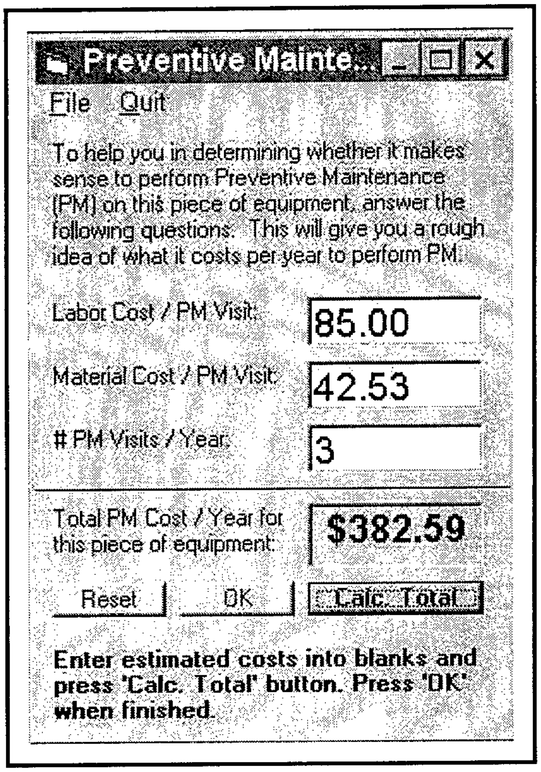

Figure A5. Preventive maintenance costs calculator.

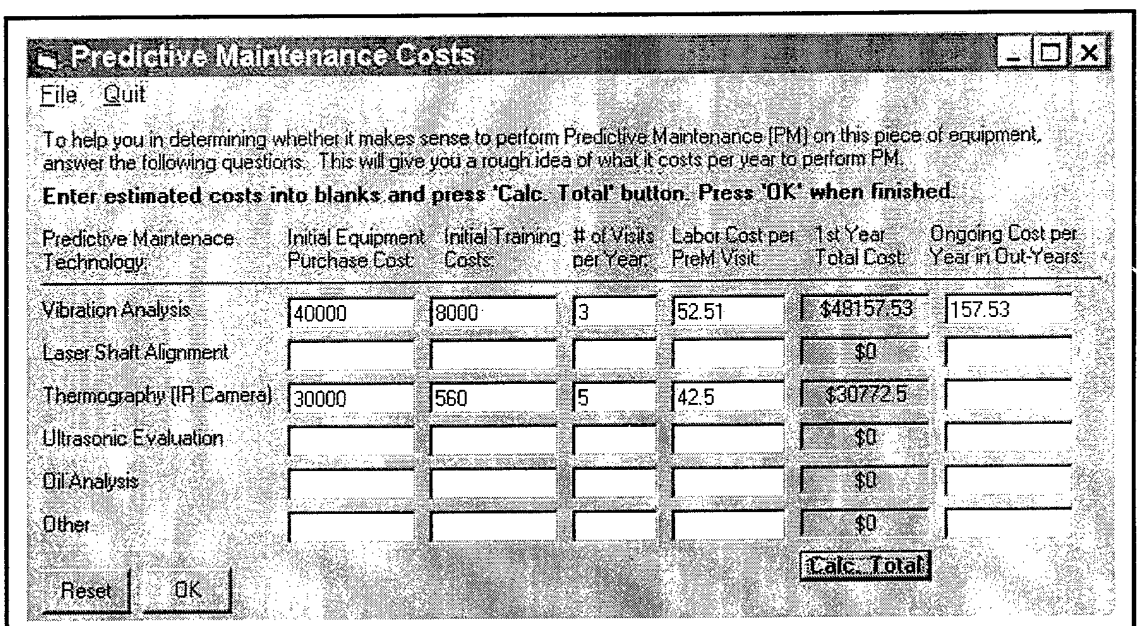

Figure A6. Predictive maintenance costs calculator.

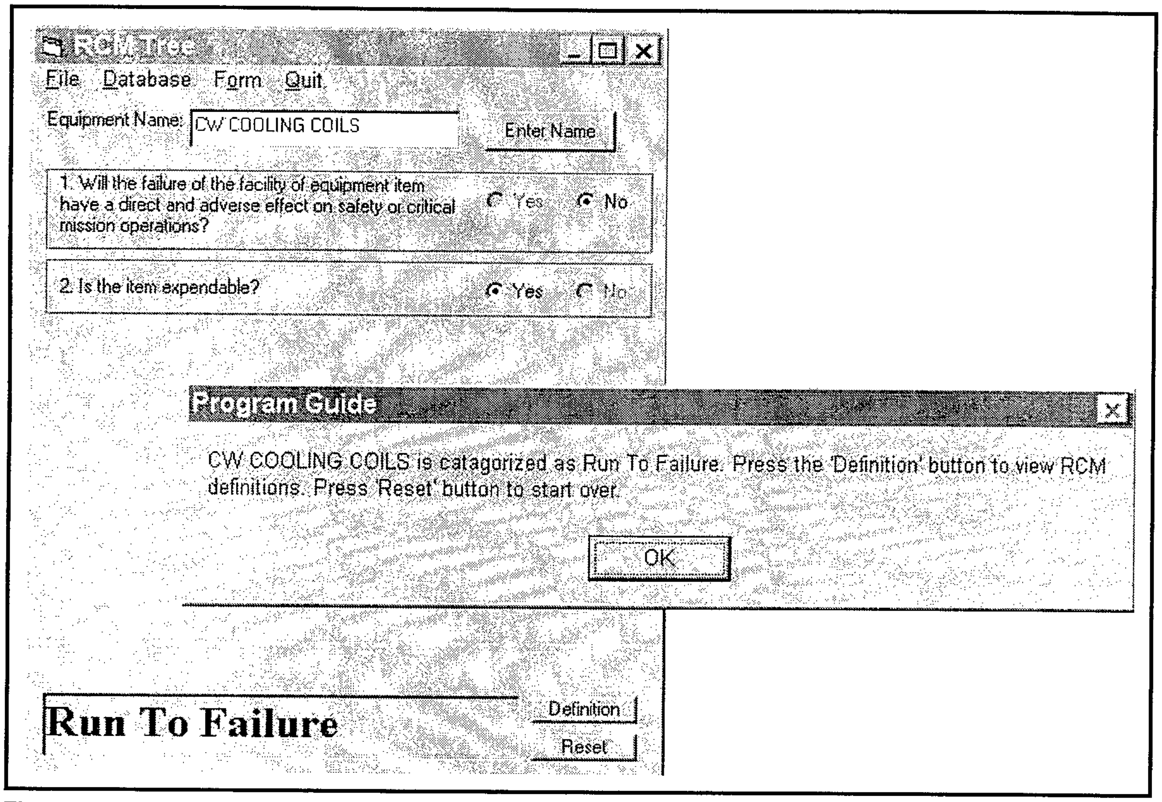

Figure A7. The program guide's pop-up boxes will offer an explanation of RCM type.

Appendix B: Setup

Setup

To Install RCM Tree, Version 1.65 (R6.exe) on Windows95:

1. Double click setup.exe

2. Accept defaults (directory locations)

3. After install, place RCMtest.mdb (database file) in the folder "C:\Program Files\R6\"

4. Copy RCM.ppt (PowerPoint® file) over to your desktop (C:\windows\desktop\)

To view tutorial and run program (after installing RCM Tree):

1. Run PowerPoint® and open RCM.ppt (double click on RCM.ppt icon to do this)

2. In PowerPoint®, run slide show

3. When you reach the slide with the link button (slide 50), click on the RCM Decision Tree button (while slide show is still running)

4. Follow the directions and explanations on the pop-up message boxes

To run program *without* tutorial (after installing RCM Tree):

1. **Double click on R6.exe**

2. Follow the directions and explanations on the pop-up message boxes

Requirements

IBM 386 compatible PC or greater

4 MB RAM or greater

Windows 95/NT

Microsoft PowerPoint® 97 (Office 97)

Microsoft Access® 97 (Office 97)

Please note:

There is no (MS Access®) database hooked up to the RCM Tree program until you place RCMtest.mdb in the directory folder "C:\Program Files\R6\". Therefore, if you have not placed the database file (RCMtest.mdb) in the right place, when you try to enter or view database information, the program will give you an error message. For the purposes of this demo, ignore the error message and click OK. It will then proceed to show you a blank data entry form that is used to enter and view information to and from an (MS Access®) database.

RCM Tree Version 1.64 and higher includes a program guide that guides the user through the program with message boxes. Version 1.63 excludes this program guide.

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